

WASHINGTON, D. C. 20024

SUBJECT: Interface Latching Loads
Case 620

DATE: June 2, 1969

FROM: R. K. McFarland

MEMORANDUM FOR FILE

Introduction

A presentation was made by J. Kotanchik, Chief, Structures and Mechanics Division, MSC, at the Apollo 10 Flight Readiness Review, April 23, 1969, reviewing analysis and test results of CSM/LM interface latching loads. The Apollo Configurations are adequately designed for these loads, however, based on presently specified limit loads for the AAP program, they could severely impact the present structural design of the AAP configurations. This memorandum reviews the operation of the latches and discusses a course of action to define quantitatively the loads that could be experienced by the AAP configurations.

Background

Prior to late 1967, the CSM tunnel was equipped with four semi-automatic and eight manual latches. The docking probe was equipped for automatic retraction such that when probe capture occurred, the probe would immediately retract, triggering the four semi-automatic latches. The remaining latches would then be set manually. The pre-load on these latches was 600 lbs. each (Reference 1). These latches were later replaced with the present automatic latches that are triggered when the two docking interfaces come within approximately .105 in. of each other, and have a pre-load of 2700 lbs. each. The automatic probe retraction mode has been removed, and the probe is now retracted by a command from the CM.

Docking Tunnel Loads

The primary concern due to the operation of the automatic latches is the bending moment induced in the tunnel structure. The present docking procedure is a sequential operation in that probe capture is first performed, residual rates between the CSM and LM are then damped out, the CSM and LM are aligned as closely as possible, and then the probe is retracted. If mis-alignment exists, one edge of the tunnel interfaces will contact first, and the sequential operation

of the latches can induce a rotational inertia or "whip" as the interfaces close. If alignment is perfect prior to probe retraction, but a C.G. offset exists in say the LM, then as the probe is retracted through the 10 in. of travel, a mis-alignment can occur prior to interface contact. The cause of the possible high loading is the triggering gap on the latches, which is .105 in., and the latch pre-load of 2800 lbs. each, which acts to close the gap between the tunnel interfaces.

For the Apollo configurations, with all latches operating, the worse case bending moment is 454,000 in.-lbs., with a 3° mis-alignment (Reference 2). The method of analysis was discussed with D. Wade of MSC on May 22. The reference report lists results from a digital program that has been developed at MSC, and checked against dynamic docking test facility results, which utilized flight type probe drogue and tunnel interface structures in a mechanical-hydraulic simulator. The data input to the digital program consist of probe drogue elastic properties, discrete docking interface elastic properties, CSM and LM inertial and elastic body properties, probe retraction force, and latch retraction forces. To verify the digital program some 2500 docking tests have been performed using the docking test facility. As such MSC has high confidence in the validity of the results, and has developed a good understanding of the docking response and the effect of the numerous variables involved.

The reported loads pose no problem to the Apollo program; CM-102 and LTA-3 were each tested to a limit-load moment of 610,000 in.-lbs. However, the AAP multiple docking adapter docking tunnels are presently designed to a limit load of 300,000 in.-lbs. The inertial and elastic characteristics of the AAP configurations are considerably different from the Apollo configurations, and it would be extremely difficult if not impossible to extrapolate AAP loads from the Apollo data.

The Apollo latching loads document was discussed with E. Beam of MSFC and G. Pfaff of the Martin Company at MSFC on May 23. Neither Martin nor MSFC has a docking analysis program equivalent to the one presently in operation at MSC.

Course of Action

The AAP specification for bending moment on the docking ports of the multiple docking adapter has been set at 300,000 in.-lbs., and was based on loads induced during docking impact. As present information from the Apollo

program indicates that the latching operation could induce a more severe loading environment, there is a distinct possibility that the multiple docking adapter ports may be underdesigned.

At present, the only operational testing facility and analytical capability applicable is at MSC, in the Structures and Mechanics Division. To perform this analysis, MSC would require inertial and elastic body properties for the AAP configurations, information they presently do not have. As test prototypes of the multiple docking adapter have been fabricated, and the structural design established, the magnitude of the latch loading for the AAP configurations should be determined soon, to minimize possible impact on the program, and to define acceptable modifications to the structures or latches, if necessary. MSC is well equipped to perform the task, if given the necessary information on the AAP configurations.

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Attachment
References

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BELLCOMM, INC.

REFERENCES

1. Bellcomm Memorandum for File, "Status of Docking System Changes", W. C. Brubaker, December 4, 1967.
2. The Boeing Company Memorandum No. 5-2961-HOU-044, "Interface Latching Loads", April 24, 1969.